Volume 27 February, 1941 *Number 2*

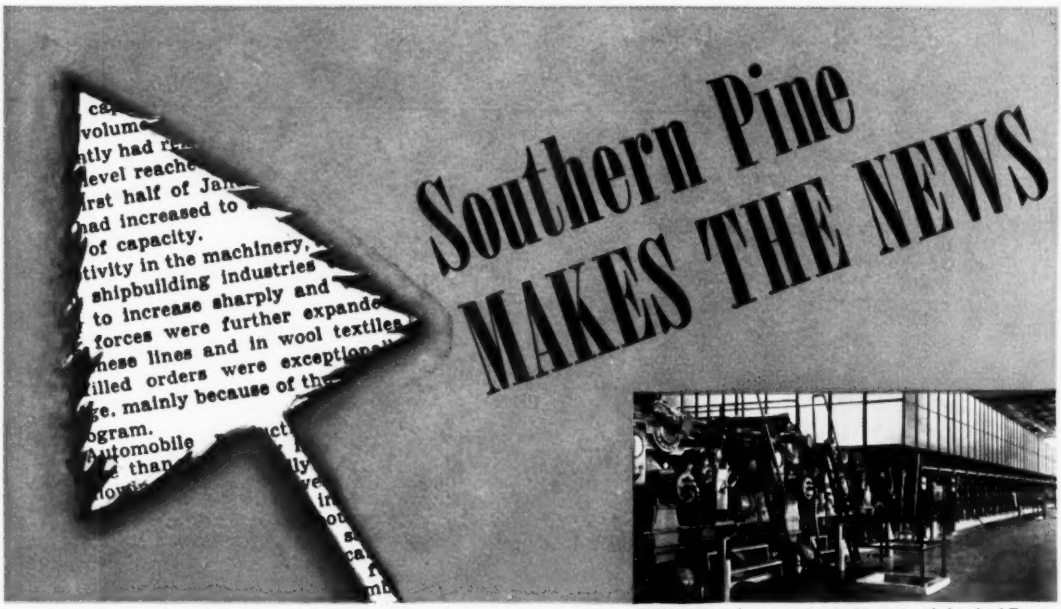
Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

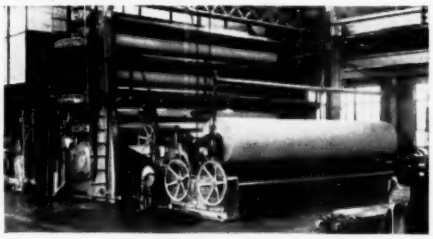
THIS ISSUE

Lubrication Requirements of Heavy Duty Roller Bearings

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS



WET END *(above) and* **DRYER END** *(below)* of Pusey and Jones Paper Machine at Southland Paper Mills, Inc., Lufkin, Texas . . . lubricated exclusively with TEXACO.



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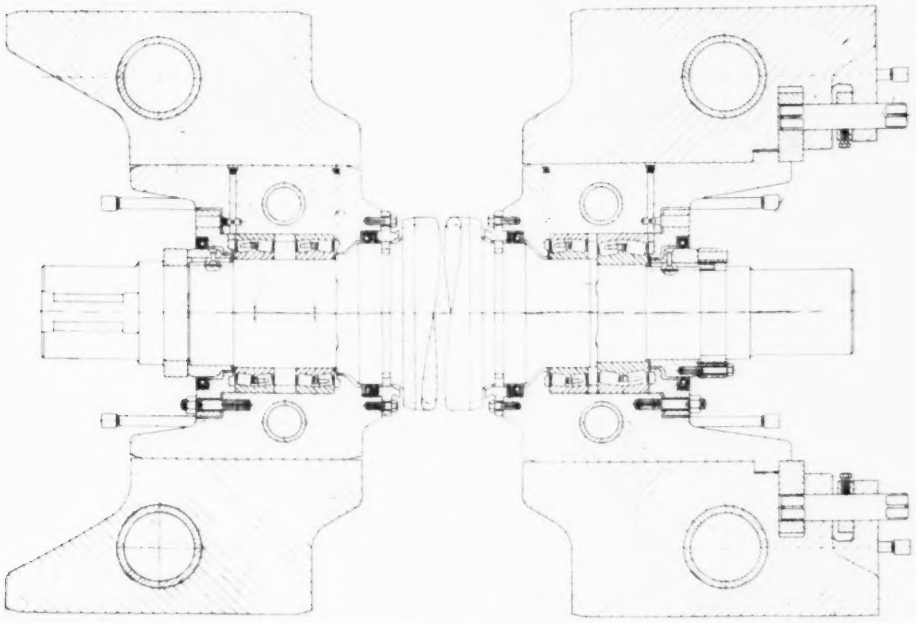
Lubrication Requirements of Heavy Duty Roller Bearings

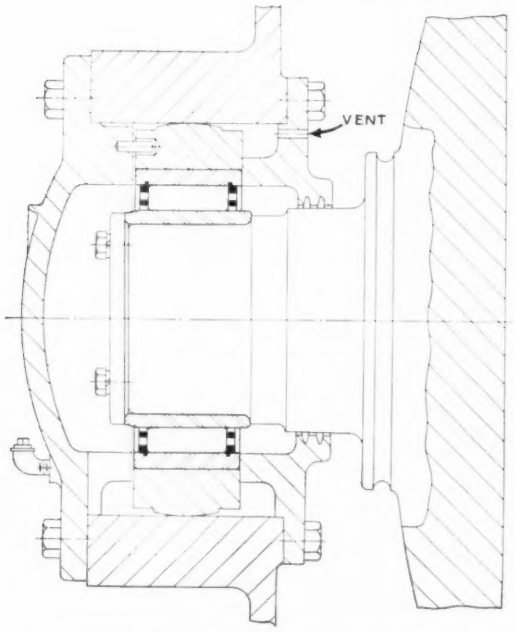


Courtesy of S. K. F. Industries, Inc.

Fig. 1—Showing the operating side bearing design for a four-high work roll mounting in steel mill service.

HEAVY duty roller bearings became a factor in steel rolling, oil field service, the paper mill, and on railway rolling stock when load conditions were increased and machinery speeded up to maintain production schedules, which have since become so important. Literally we live, read, and ride on the roller bearing. This development has been accompanied by the perfection of bearing closures, seals, methods of lubrication, and extensive laboratory research by the petroleum industry. The latter has concentrated their study upon methods of compounding and the selection of the component materials, in order to produce greases which will be capable of withstanding the intensive conditions which usually prevail. These lubricants must meet load conditions which are frequently excessive;

vibration which may be continuous; water conditions which may approach flood nature; and in steel the shocks which result from the impact of ingots or billets upon the rolls.



Courtesy of Hyatt Bearings Division General Motors Corporation

Fig. 2—Details of a dryer cylinder on a paper machine. Note provision for draining and venting the bearing housing.

Steel Mill Loads Reactive

Unless the reacted loads can be carried by the roll neck bearings and can be withstood by the lubricants and unless there is adequate provision to prevent squeezing out and leakage of these lubricants, the life of the bearings will be adversely affected. Furthermore, if water, paper stock, mill dust, or dirt penetrate within the bearing assemblies, the lubricating ability of any type of lubricant involved will be reduced.

In addition to load, shock, and contamination, the effect of heat and speed must be counteracted. Heat prevails in steel rolling and on the dryer end and calender stack of the paper machine. It is difficult to predict just how high the actual film temperature may be in a steel mill roll neck or run-out table bearing, but hot metal proximity assures us that it may often be above 250 to 300 degrees Fahr., or sufficiently high to cause considerable vaporization of some types of lubricating oils. This is one of the primary reasons why the petroleum research chemist watches his crude evaluation so carefully, in order to select only those oils which are so closely fractionated as to be able to resist such vaporization. These oils are the petroleum component of heavy duty bearing greases today.

Temperature Control

Water-cooling controls this heat condition to a considerable extent, so both the steel and paper industries make good use of extensive water-cooling systems. Just how far the temperature may be reduced depends, of course, upon the volume of water circulated and the inlet temperature. The greater the temperature difference between the inlet and outlet water, the more effective the cooling. The actual effect of this upon the lubricating film can be ascertained roughly by thermoelectric observations, or by thermometers installed in wells drilled in the bearing pedestals or housings. Thermocouples are most positive, but also most costly. Hence they are not so widely used as the thermometer. At best, however, constructional conditions render it difficult to determine quite accurately the temperature of the lubricant in a roller bearing.

Speed

Speed, in turn, is continually increasing. In strip steel production, surface speeds of roll necks used to range from 1500 to 2000 feet per minute. Today they are well above 2000 feet, and limited only by the ability to synchronize the speed of the coiler. This latter must be reduced continually as the diameter of the coil is increased. Today, surface speed limits of 5000 feet per minute are discussed.

Paper Mill Service

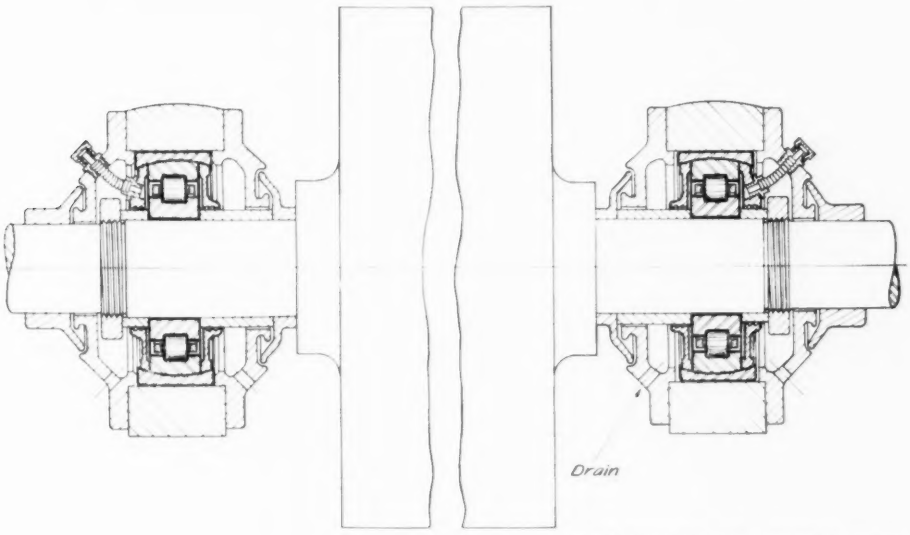
In lubricating paper mill machinery, a similar variety of problems prevail. Starting with the products, one must not only take the utmost care to protect the lubricants themselves in storage and transit to the lubricating systems, but also every consideration must be given to the detriments and cost of oil-contaminated paper and felt surfaces. Service conditions in the paper mill involve high pressures, high temperatures, and the possibility of entry of water or paper stock into the lubricating systems. Obviously, this would affect the cost of production, so paper mill executives, machinery builders, and the petroleum industry have all collaborated in developing means of counteracting premature bearing failure, protection of paper stock, and the establishment of methods of lubrication.

These activities have paralleled those which prevailed in iron and steel, featuring as they did the furtherance of the heavy duty roller bearing, the perfection of bearing seals, and design of methods of automatic lubrication, where circulation of oil or pressure delivery of greases could be used to advantage. Through-

out, it has been a program of mutual protection for bearings, drive gears, pinions, and lubricants.

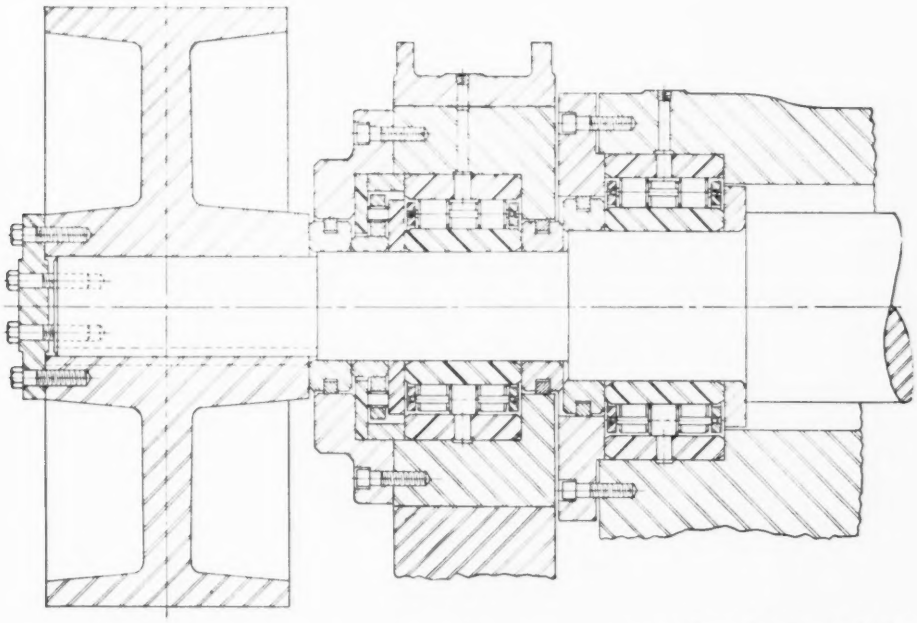
which keep them in proper position with respect to the inner and outer races.

Alignment is most important in roller bear-



Courtesy of Norma-Hoffmann Bearings Corporation

Fig. 3—A breast and wire roll mounting for a high speed fourdrinier machine. Note points for lubrication and draining, also methods of sealing.



Courtesy of Orange Roller Bearing Co., Inc.

Fig. 4—Details of a staggered roller bearing mounting for heavy duty service.

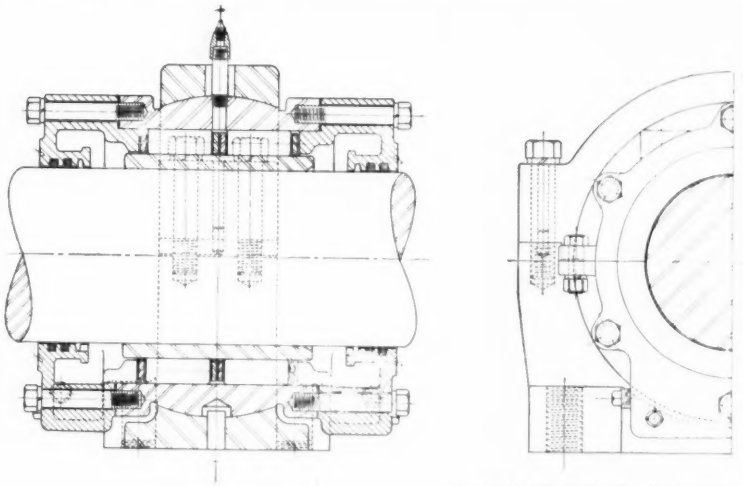
Contact Area

The heavy duty roller bearing may be built to a number of designs. These include cylindrical, barrel-shaped, tapered and cylindrical-helical rollers, carried in suitable retainers

ing operation. The actual contact area of a roller bearing is rectangular. This must be maintained without deviation, for skewing of a roller may throw the entire bearing out of line, to result in uneven load distribution and

wear. In other words, the axes of the rollers must be in the same plane as the axis of the rotating shaft. Proper guiding has been found to be the most effective way to keep the rollers from skewing; this is a function of the guide flange. Obviously, it becomes more difficult as rollers are increased in ratio of length to diameter.

While one objective is attained, another is aggravated by the sliding motion which is developed between the ends of the rollers and the end plates or race flanges. Here steel-to-steel contact exists, presenting a condition which requires continuous renewal of the lubricating film.



Courtesy of The Fafnir Bearing Company

Fig. 5—A grease lubricated double row bearing pillow block. The ample grease chamber and felt grooves insure of retention of adequate amounts of lubricant.

FUNCTION OF THE LUBRICANT

In roller bearing service the lubricant performs a four-fold duty, viz.:

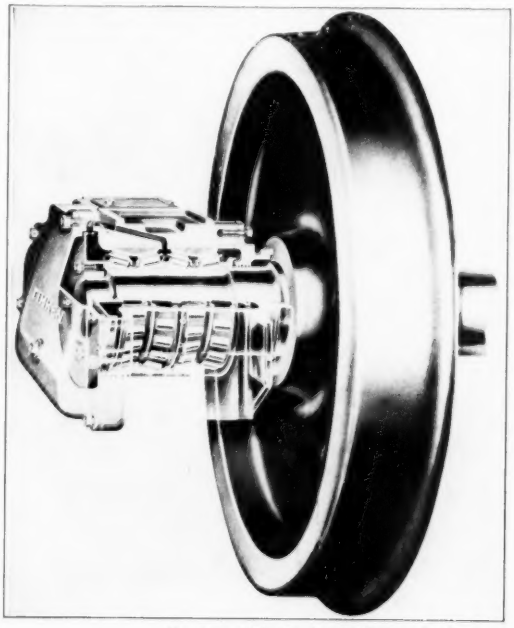
(1) It protects the surfaces of the bearing elements against corrosion.
(2) It assists the seal in preventing water or dirt from coming into actual contact with the bearing surfaces.
(3) It serves as a conductor of heat, to aid in bearing cooling.
(4) It functions as a lubricant to enable free rolling of the rollers, and sliding between the rubbing surfaces of the shoulders and rollers.

A free-flowing lubricant at the prevailing operating temperatures will most nearly lead to the attainment of these objectives. By this term is meant a grease or oil which will "train" readily with the rollers, yet channel sufficiently so that actual churning does not occur. Excessive churning will build up the torque through internal resistance within the lubricant itself. This frictional effect leads to heat development which may easily build up the bearing temperature beyond the cooling ability of the lubricant, at times even beyond the cooling ability of the external cooling system.

Cleanliness Reduces Bearing Wear

We have spoken of the seal as an adjunct to cleanliness. Obviously, it is important to keep out abrasive foreign matter. But it is also quite as important to use clean, dirt-free lubricants, otherwise the purpose of the seal is offset.

Abrasive particles in a grease, especially, will cause rough rolling of the bearing. When this occurs in a freshly lubricated element, it signifies abrasion. At first this may be very slight, and when the bearing comes up to speed, it may not be noticeable. But abrasion is going on just the same, until, dependent upon the amount of dirt, the speed and the size of the bearing, loose rolling or chattering will develop. At the same time, the heat at the contact points may be so high as to assist in oxidation-

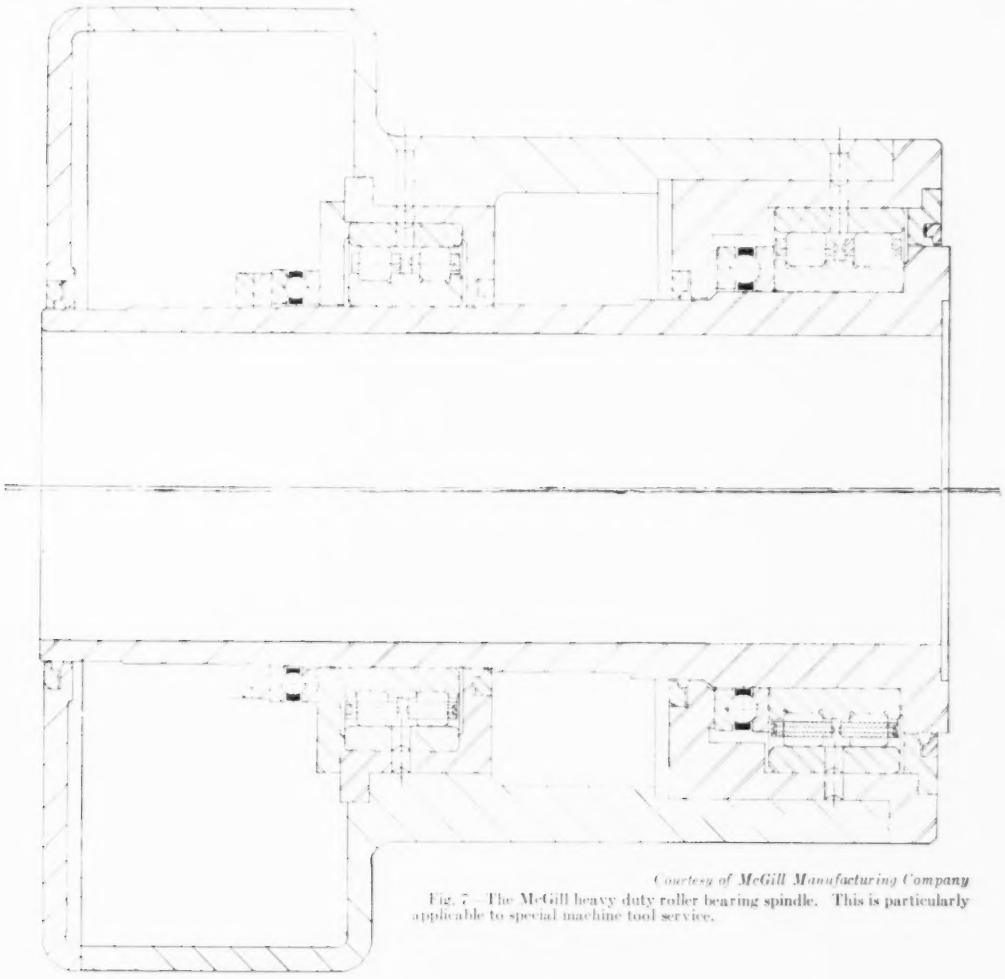


Courtesy of The Timken Roller Bearing Company

Fig. 6—A Timken "4-row" railroad bearing application which interchanges with all sizes of friction bearings and fits into existing trucks without change.

breakdown of the lubricant. Then gums and lacquers form. The only recourse is thorough cleaning, drying, and relubrication of the bearing parts before wear has occurred to such an extent as to require bearing replacement.

replenished or renewed at periodic mileage intervals. In contrast, paper mill roller bearings can be lubricated effectively by oil circulation from a centralized system. This presents certain very definite advantages for bearings



Courtesy of McGill Manufacturing Company

Fig. 7.—The McGill heavy duty roller bearing spindle. This is particularly applicable to special machine tool service.

LUBRICANT CHARACTERISTICS

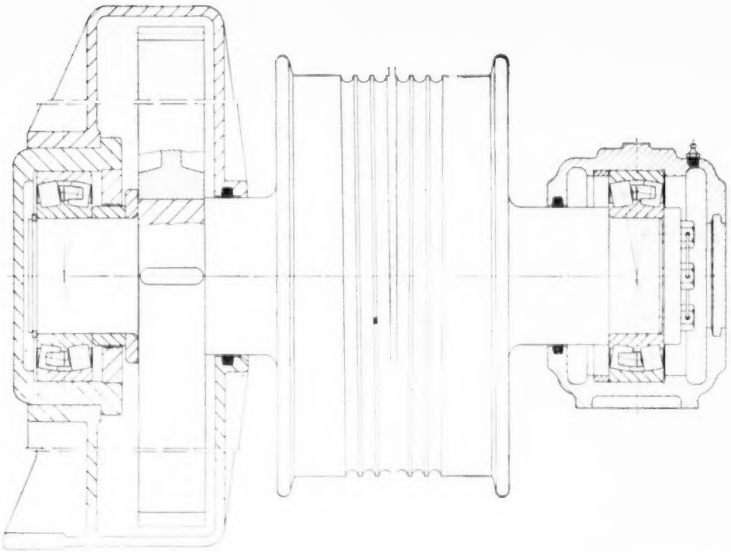
Lubricating greases and petroleum lubricating oils for heavy-duty bearing service must possess very definite characteristics. In turn, these latter must be evaluated according to the nature of the service involved, likewise the means available for re-lubrication.

Bearings designed for oil lubrication must be equipped with especially-prepared seals, the duty of which is to prevent oil loss through leakage; also, to keep out water or contaminating foreign matter. They may be served with measured quantities of oil or provided for oil circulation. The former is characteristic of the railway roller bearing which is built as a unit-lubricated mechanism, the oil charge being

on the dryer end of the paper machine, for a continuous and dependable supply of lubricant is always present, the circulation of which develops a flushing as well as a cooling action. Furthermore, the bearing housing can be so designed that there is a free flow of oil through the entire elements with but little chance for churning. Finally, continuous reconditioning of the oil supply keeps it in good condition and free from non-lubricating materials which might otherwise affect bearing performance.

Refinery Procedure

Lubricating oils for such service must of necessity be refined to a wide range of viscosities in order to meet the prevailing operating



Courtesy of S. K. F. Industries, Inc.

Fig. 8—A spherical roller bearing applied to an auxiliary drum mounting in crane service. The bearing in the cartridge housing (adjacent to the gear case) is free to locate itself axially.

conditions. Conservatively, it may be stated that this range will average from 50 to 175 seconds, Saybolt Universal Viscosity at 210 degrees Fahr.

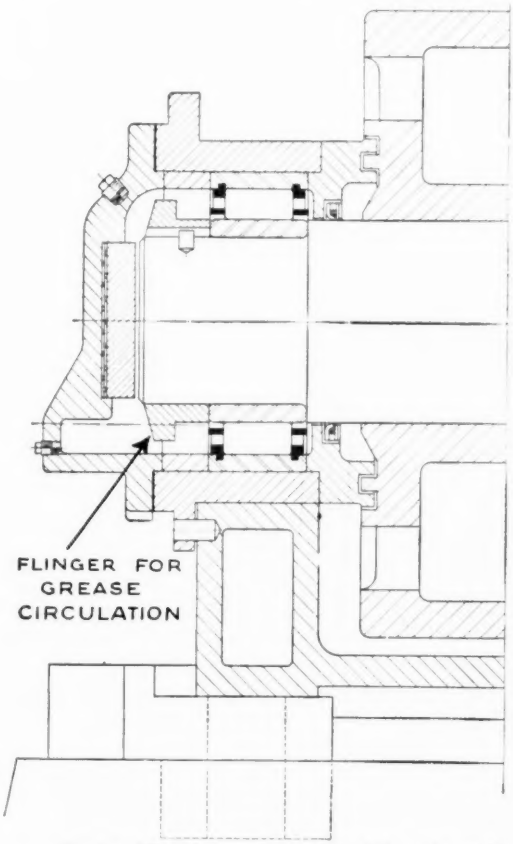
The operating temperatures largely control the initial viscosity of the oil. Load conditions are a secondary factor. It is presumed that all such bearings are heavy duty, so they carry more load than the average anti-friction bearing in other types of industrial service. The speeds, however, will be lower in steel, paper, oil field, and railway service, rarely exceeding 2,000 r.p.m. The peripheral or surface speed will of course depend upon the size or diameter of the shaft, journal, or roll neck.

Lubricating oils are refined to any specific viscosity by selection of the proper cuts during distillation. Lighter products, ranging say up to 100 seconds S.U.V. at 210 degrees Fahr., are wholly distilled materials or the products of overhead condensation of petroleum vapors. Heavier oils may be residual products or blends of the two, according to their viscosity. This process of distillation controls the quality of the resultant oils only insofar as fractionation of the vapors is controlled to segregate hydrocarbons within a narrow boiling point range. Of necessity this must be closely watched in refining oils for ball and roller bearing lubrication. An oil composed of hydrocarbons of a wide boiling point range would tend to vaporize to excess at elevated temperatures, causing loss of oil and increase in the viscosity of the remainder.

Residual oils are often used in heavy duty roller bearings, especially where high temperatures may develop. The quality of such oils depends upon the manner of refinement. Refining processes as perfected today remove the non-lubricating tarry matter and amorphous waxes, producing a stable, heat-resistant lubricant.

Load Carrying Capacity

The load carrying capacity of an oil or grease can be improved by use of certain selected additives. In heavy duty roller bearing service, methods of refinement have produced straight mineral lubricating oils capable of meeting the prevailing loads, when circulated or applied under controlled temperatures which will enable taking full advantage of the viscosity.



Courtesy of Hyatt Bearings Division General Motors Corporation

Fig. 9—A cement kiln roller bearing installation. Note the flinger for lubricant circulation, also provision for re-lubrication, and draining when cleaning is necessary.

in other words maintaining a constant lubricating film which is not unduly thinned down by heat. So the paper machine, oil field machinery, or railway journal roller bearing customarily functions on a straight mineral oil where the bearing is designed for oil lubrication.

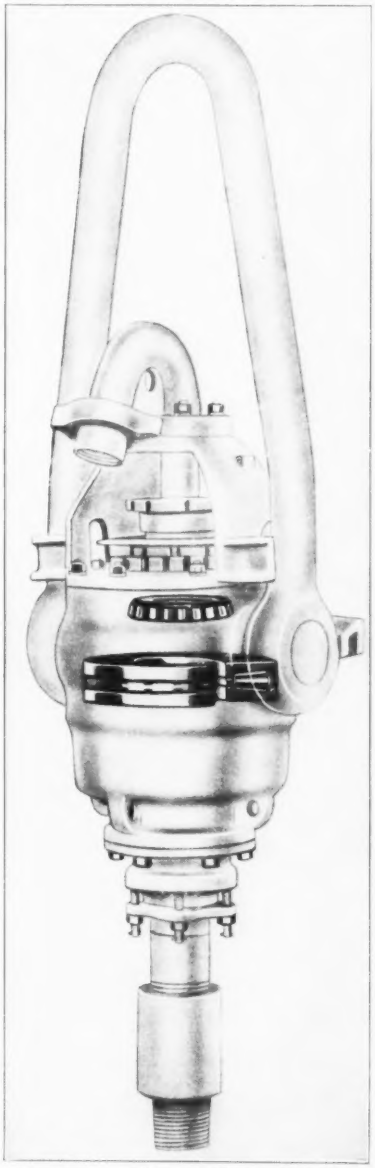
Grease Manufacture

The manufacture of greases suitable to the heavy duty roller bearing must be approached not only from the angle of the actual lubricating requirements, but also with due regard for the ability of the lubricating systems to handle the finished grease. In other words, certain definite pressures are available for grease distribution through the lubricating system, according to the design of the pressure pumps. Some can handle heavier greases than others; some distributing systems have more sensitive valve elements than others; and the length and diameter of the distributing lines are different in almost every installation.

But a specialty grease cannot be manufactured for each. So the grease chemist must study the prevailing operating conditions as a group.

He begins with careful selection of the fatty oil and alkali which are used to make the soap base; then he selects a range of straight mineral oil viscosities which are best adapted to the prevailing temperature conditions. All these basic materials must be of a high degree of purity and free from contaminating foreign matter. The manufacturing procedure must then combine them so that the finished grease will be uniform in composition and texture, resistant to chemical breakdown, non-water-soluble, and structurally capable of being pumped through long distributing lines without danger of oil separation. These distributing lines should never be less than one-half an inch in inside diameter.

In grease manufacture, the use of additives to increase the film strength has been given quite extensive consideration. The petroleum industry was impelled to research study in this regard when the steel industry designed for high speed rolling of strip steel. As a result, rolling mill work and back-up rolls on both hot and cold strip mills, table rolls and much of the other attendant machinery are now equipped with heavy duty roller bearings designed for pressure grease lubrication, for which certain bearing manufacturers make specific recommendation of extreme pressure greases.



Courtesy of The Timken Roller Bearing Company

Fig. 10—Cut-away view of a modern oil field swivel showing The Timken thrust bearings.

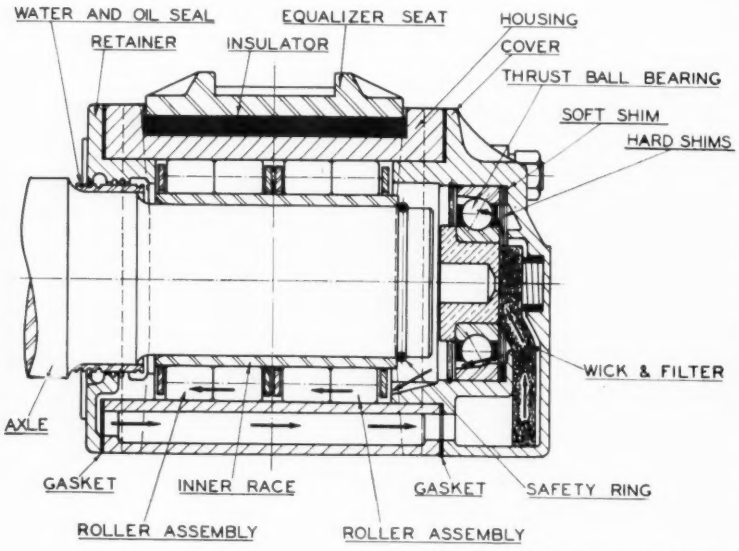
We have already mentioned certain of the procedures which the grease chemist must follow. In addition, it is well to state that he is most careful in his selection of E.P. additives, and later in their compounding. He fully realizes the detriments which might ensue were these to develop an abrasive or corrosive action.

Water and Heat

These factors must also be studied by the grease chemist, for he must consider the solubility, effect of water upon his soap stocks, and also the viscosity-reducing effect of heat on the viscosity of his mineral oil. Lime soap is insoluble in water, so it is widely used as the soap base for certain steel mill greases where an excess of hot water may be present. For the paper industry either lime soap or soda soap can be used in grease manufacture, the choice being contingent upon the tightness of the bearing seal, the temperature and the amount of water present.

Where soda soap or mixed (lime-soda) base greases are involved, it is well to remember that the solubility tendency will increase with the temperature of the water. In other words, on the wet end of a paper machine, certain specialty soda or mixed base greases may be capable of functioning quite satisfactorily where the water in contact with them does not range much above room temperature. Whereas, in steel rolling, where water is used for

scale breaking, an excess of hot water approaching the boiling point might render these same lubricants entirely unsatisfactory.



Courtesy of The Fafnir Bearing Company

Fig. 11.—The Fafnir Roller Journal Box in which the radial load is carried by hardened steel rolls, while the lateral thrusts are taken up by high-capacity ball bearings.

METHODS OF LUBRICATION

Centralized lubrication developed by pressure through some form of circulating system has accompanied the perfection of some very interesting roller bearing installations in steel, the paper industry and on railway rolling stock. Furthermore, this combination has enabled the use of highest quality lubricating oils and greases, a fact which has contributed markedly to reduce maintenance costs through more positive protection of the bearing elements.

Pressure grease lubrication by positive delivery of measured quantities of grease at periodic intervals has been actively studied and a variety of systems have been perfected. All have been designed to assure the exclusion of non-lubricating foreign matter, economy of lubricants, minimum hazard in handling and filling and remote control. These advantages prevail in any installation involving heavy-duty roller bearings. The manner in which the pressure is applied, however, will depend upon the type of service and the number of bearings involved.

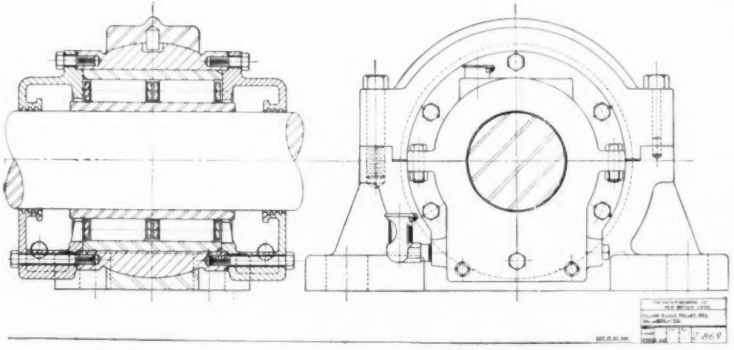
Unit lubrication prevails in railway service, on the wet end of the paper machine, and in many oil field installations; in steel on the other hand centralized pressure systems operated from a universal control panel serve the run-off table bearings and other similar units.

In all, power in some form or other must be used. Where positive piston displacement types of metering valves are employed at each point to be lubricated, hydraulic power has been found to be especially adaptable as a means of valve control. In such a system as designed for table rolls, and the bearings of the coiler and other heavy duty machinery, either one or two lubricant supply lines can be connected to each valve according to the nature of the service.

Where two lines are employed, pressure is applied alternately, each line receiving pressure over a prescribed period during which this line discharges each of the valves. The time between pressure applications will serve as the time interval between operations of the system.

In the single line system, the required grease pressure is developed by using an hydraulic fluid for transferring the power from the electric motor to the grease pump itself. By employing a large piston, subject to very slow motion, a considerable quantity of grease can be handled, air pockets are effectually eliminated, and the system gives long and satisfactory service.

There are other types of pressure greasing

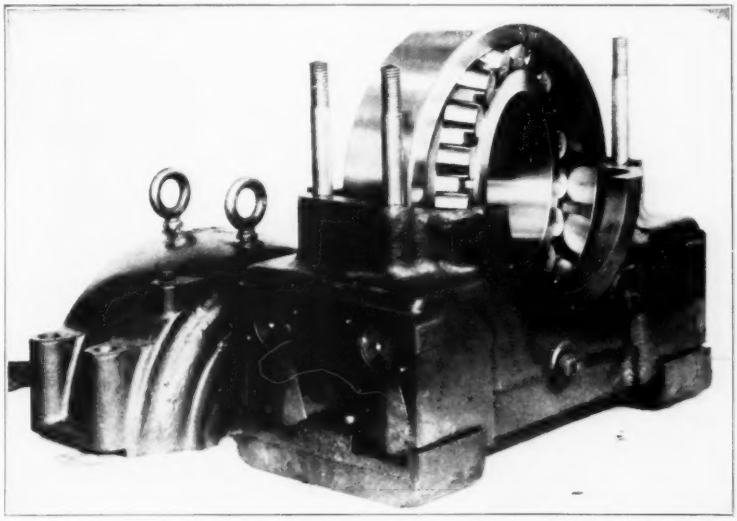


Courtesy of The Fafnir Bearing Company

Fig. 12—An oil lubricated double row bearing pillow block. Note large oil reservoir and sight-feed oil fittings which minimize maintenance attention.

systems which require electric power or compressed air for their operation. Some of them are designed to eliminate the necessity for springs, check valves or restricted port openings.

Where intermittent pressure is exerted upon the lubricant between operations of the system, the lines are under no pressure. This type of operation gives the grease the best conditions under which to operate, assures of positive flow and assists in the elimination of air pockets. These are always objectionable, although their development will depend to some extent upon the body of the grease; the heavier the latter, the greater the possibility of such air pockets.



Courtesy of S. K. F. Industries, Inc.

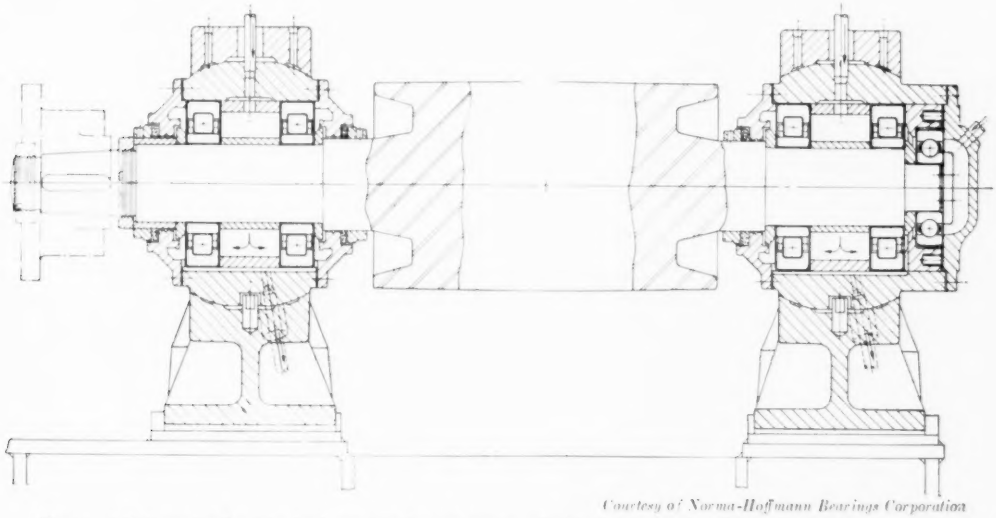
Fig. 13—A unique method of mounting the housing of a roller bearing on "rockers". Circulating oil lubrication is employed on this unit which is designed for the tending side of the dryer cylinders on a Kraft paper machine.

Unit Grease Lubrication

Unit lubrication has also been developed to a high degree of efficiency. By this term is meant the treating of each machine as a unit, with a built-in individual lubricating system. In this way interference with the lubrication of any particular machine enables segregation of that unit. During the repair or overhaul period, grease lubricated parts can be protected by hand lubrication. This will enable the plant or mill to continue running with no time loss or interference with production. Under such emergencies the portable pressure gun has been found to be an excellent stand-by device.

IMPORTANCE OF LUBRICANT SEALS

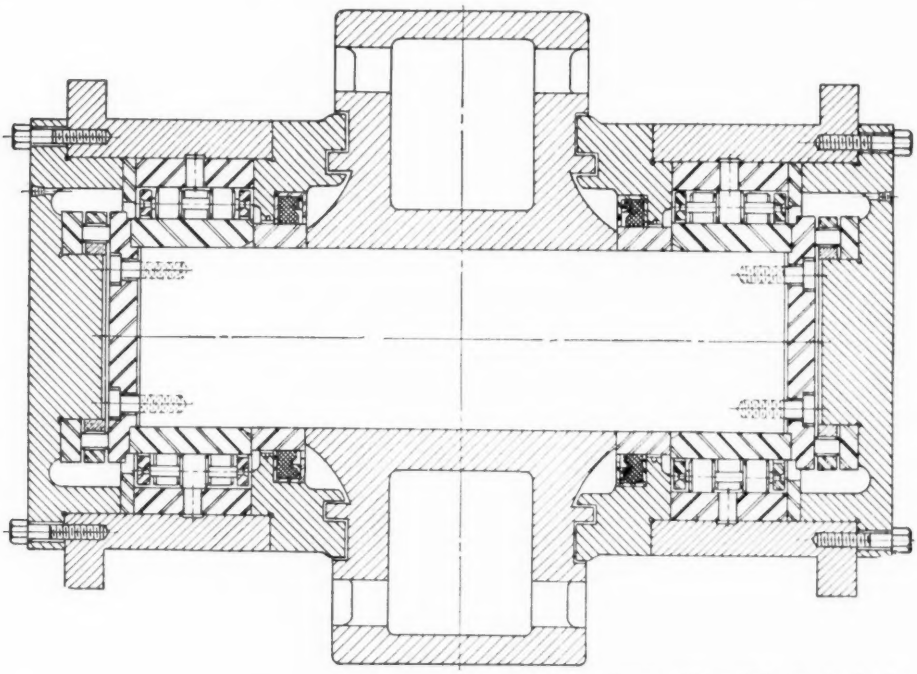
The development of the heavy-duty roller bearing has been particularly noteworthy from the viewpoint of the efforts of the designers to work out effective lubricant sealing features in the form of labyrinths, slingers, seal rings, and cup type seals. Retention of the lubricant was early appreciated as being a most important feature. Obviously, protection of the



Courtesy of Norma-Hoffmann Bearings Corporation

Fig. 14—A high speed pulley drive for heavy duty hot saw service. Positive lubrication for all the roller bearings is assured by oil circulation, and a combination of grease and labyrinth seals to prevent contamination.

surfaces of the bearing elements could not be assured were leakage of lubricants to prevail, and with this lack of protection, failure of a bearing under intense load might easily occur.

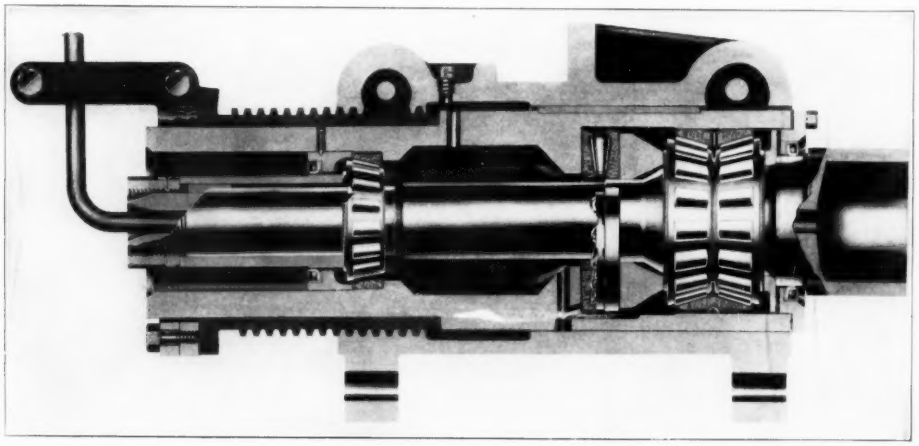


Courtesy of Oranje Roller Bearing Co., Inc.

Fig. 15—Application of the staggered roller bearing to the trunnion roller on a rotary kiln.

It was also important to study sealing devices by reason of the high temperatures under which this will occur depends of course upon the original body of the product. Unless the latter is comparatively heavy, considerable leakage may result from certain types of bearings when exposed to high temperature.

Where an adequate bearing seal can be pro-



Courtesy of The Timken Roller Bearing Company

Fig. 16—Details of piercing mill thrust block showing tapered roller bearing application for radial and thrust purposes.

which so many steel and paper mill bearings, in particular, must operate. The effect of such temperatures is to reduce the viscosity or consistency of any lubricant. The extent to vided, as is customary in the design of the majority of roller bearings employed in such service, leakage, even under extreme temperatures, can be prevented to a marked degree.

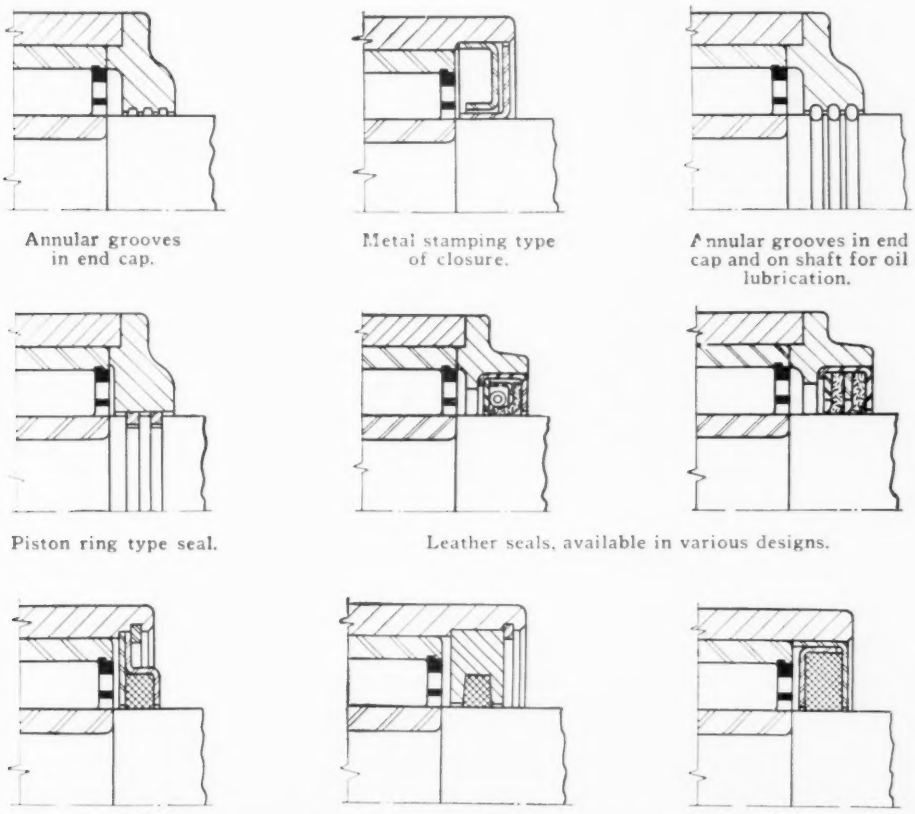
In this connection, a discussion of the various types of seal design will be of particular interest.

In the earlier developments of sealing media, felt and leather washer and grease-groove seals proved their adaptability and were comparatively inexpensive and simple in design. By virtue of these advantages, they are still retained by many bearing manufacturers. Since their development, however, other types of seals have come into usage including metallic rings similar to piston rings, mercury baths in connection with vertical installations, and metallic springs for the purpose of maintaining the adjustment of the seal material with respect to shafting, journals or roll necks.

The primary objective in the selection of a suitable grease or oil seal is to obtain a design which will not show material wear in service, otherwise the purpose may be more or less defeated. Washer type felt, leather or synthetic material seals may have this tendency, although the rate of wear will depend upon the quality of the material. Where adjusting springs are used in connection with similar material, however, to automatically keep the seal in close contact with the shaft or journal surface and thereby compensate for wear, dependable retention of lubricant is accomplished.

Grease groove seals present a comparatively simple means of overcoming leakage of lighter lubricants under normal temperature conditions. They are also relatively simple and inexpensive to design. On the other hand, they require attention at periodic intervals, for the purpose of renewing the sealing grease. Otherwise, possible glazing of the surface of this grease where it comes in contact with the rotating shaft might result in sufficient clearance to allow leakage of the bearing lubricant. Very heavy bodied greases of high melting point are adaptable to service as grease seals, provided they show no tendency to separate oil from soap, and contain no material which might prove abrasive to the shaft surface. Grease grooves can also be used together with felt washers in certain types of service.

While spring adjusted seals insure more uniform contact between the sealing medium


Annular grooves in end cap.
Metal stamping type of closure.
Annular grooves in end cap and on shaft for oil lubrication.
Piston ring type seal.
Leather seals, available in various designs.
Typical closure designs showing use of felt seals.

Courtesy of Hyatt Bearings Division of General Motors Corporation

Fig. 17—A variety of bearing closures showing method of design, manner of location and materials used.

and the shaft, journal, or roll neck, they involve more constructional details and consequently can normally be expected to be more expensive than the more simple types of washer seals.

Water a Basic Objection

In steel mill and paper service, sealing against the entry of water must be very carefully studied. Scale is an added potential lubricant contaminant in the steel mill, while paper stock often presents a problem in the maintenance of paper mill bearings. The bearing seals, of course, control the extent to which such materials may penetrate and interfere with lubrication.

As generally constructed, the heavy duty roller bearing is well adapted to the retention of lubricant. In considering its design with respect to this ability, when selecting any grease, the influence of high temperature must also be studied. It has already been noted that lubricants become thinner or more fluid as temperatures are increased. This may lead to leakage if the seals are at all worn. Operation in the presence of hot water will oftentimes accelerate this, even sometimes resulting in leakage of water into the bearing itself. For this reason, any grease for such service must be specially prepared so that it will be as water-resisting as possible. Likewise, it must resist chemical breakdown, withstand undue reduction in body, and retain its oil satisfactorily

High Temperature May Affect the Seal

Certain types of seal materials are affected by heat, to the end that their molecular structure is changed, or some parts thereof destroyed. In reality, retarded combustion may take place. This is particularly true of animal material such as the hair used in felt, or leather, or rawhide. Opinion is divided as to what, if any, effect results from contact with petroleum lubricants; it would all depend upon the stability of the latter and their resistance to chemical dissociation. Petroleum oils will lose certain of their lighter hydrocarbon fractions when subjected to heat; this is indicated by increase in viscosity; but it is no indication of chemical breakdown. The latter is evidenced by subsequent gum formations on adjacent metallic parts.

Deterioration of seal material obviously may impair the sealing ability, to cause subsequent leakage, leading to loss of lubricant from the bearing, or entry of water. Either is conducive to impaired lubrication, and presents the possibility of bearing failure.

Hence the necessity for careful study of the makeup of the seal, with due regard for the probable operating temperatures.

DRAIN PLUGS

By virtue of the necessity for periodic cleaning of bearings subjected to heavy duty under dirty conditions, it is highly advisable that suitable provisions be made in the base of the housing for drainage of lubricant and slushing fluid. Normally a suitable plug which can be securely screwed into a drilled and tapped hole will serve the purpose and prevent leakage during operation. Oftentimes this can be elaborated upon where oil is employed for lubrication by an arrangement of nipples and pipe fittings, terminating in a sight gauge glass. In this way cleaning is facilitated, and the oil level in the bearing can be observed.

It is important to remember that the maximum protection of any anti-friction bearing is only assured by maintenance of the lubricating system as free from water and foreign matter as possible. In certain types of operation, this can be more easily accomplished than in others; the extent to which dust, dirt, metallic chips or scale may be present in the air or thrown onto the bearing will, of course, be an influencing factor. In steel mill operations this must be particularly borne in mind in the design of anti-friction bearing seals as well as provisions for cleaning, for there is always possibility of entry of non-lubricating abrasive impurities where such a bearing is not properly sealed. The detrimental results which would develop in the form of scored bearing elements, misalignment and the necessity for bearing replacement, with the attendant effect upon production, can be readily realized.

Probably the most intensive duty to which such a bearing can be subjected is continued churning of abrasive foreign matter with oil or grease in intimate contact with the highly polished bearing elements.

As it is not always possible to provide adequate sealing or to depend upon the seal being in proper condition, bearings in service such as is involved in the average mill should be flushed and cleaned periodically. The frequency, of course, will depend upon the design of the bearing, the type of seal, the extent to which dust, dirt, scale or water may be present, and the nature of the lubricant. Some classes of steel, oil field or paper mill service will be more subject to contamination of lubricants than others. Roll neck and table roll bearings for example may suffer in this respect more than those used on cold saws, although the use of oil slingers fastened to shafts or journals have been found to prevent entry of too much foreign matter effectively. Yet, even with such precautions, cleaning of the bearings should not be neglected, for experience has proved that their life can be materially lengthened by such attention.

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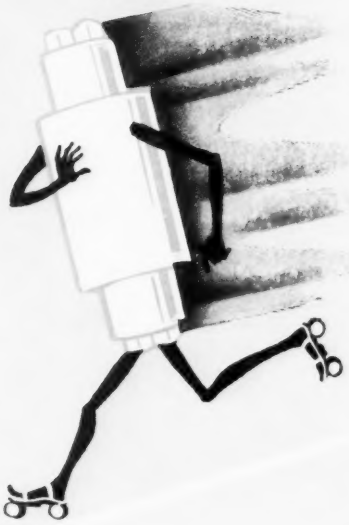

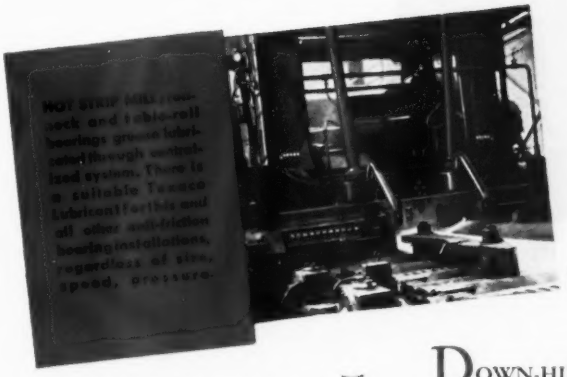

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